Lesson 3.2.1
Using Lines to Make Predictions

STUDENT NAME _____ DATE _____

INTRODUCTION

Statistical methods are used in forensics to identify human remains based on the measurements of bones. In the 1950s, Dr. Mildred Trotter and Dr. Goldine Gleser measured skeletons of people who had died in the early 1900s. From these measurements they developed statistical methods for predicting a person's height based on the lengths of various bones. These formulas were first used to identify the remains of U.S. soldiers who died in World War II and were buried in unmarked graves in the Pacific zone. Modern forensic scientists have made adjustments to the formulas developed by Trotter and Gleser to account the differences in bone length and body proportions of people living now. You will not use Trotter and Gleser's formulas in this problem, but you will use a similar process.

Note: For information on the Terry skeleton collection, see http://anthropology.si.edu/cm/ terry.htm. For a more recent example of how forensic scientists are still building on the work of Trotter and Gleser, see the following:

- Jantz, R. L. (1993). Modification of the Trotter and Gleser female stature estimation formulae. *Journal of Forensic Science*. *38*(4), 758–63.)

To illustrate the type of data analysis done in forensics, let's see if you can identify a female student based on the length of her forearm. The mystery student has a forearm measurement of 10 inches. (She is alive and healthy!)

Height and weight measurements for three female college students are given in the table.

	Jane Doe 1	**Jane Doe 2**	**Jane Doe 3**
Age	18	23	33
Gender	Female	Female	Female
Height	5 feet, 5 inches	5 feet, 2 inches	6 feet
Weight	128 pounds	120 pounds	155 pounds

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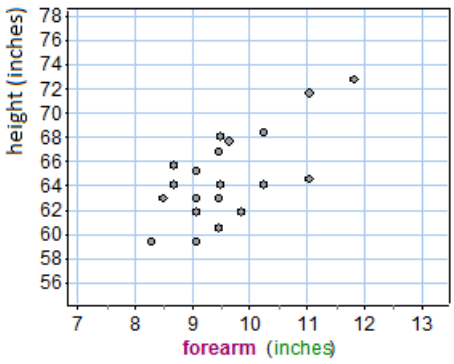
Your task is to determine if the mystery student could be one of these three students.

First, you need data that relates forearm length to either height or weight for females. The scatterplot is a graph of height versus forearm length for 21 female college students taking Introductory Statistics at Los Medanos College in Pittsburg, California, in 2009.



1 Based on the scatterplot, what is a reasonable prediction for the height of the mystery student? Briefly explain or show how you made your prediction.

2 The variability in the data makes it difficult to determine if one of these students is the mystery student. Could any of the three students be eliminated as a possibility of being the mystery student? Explain your reasoning.

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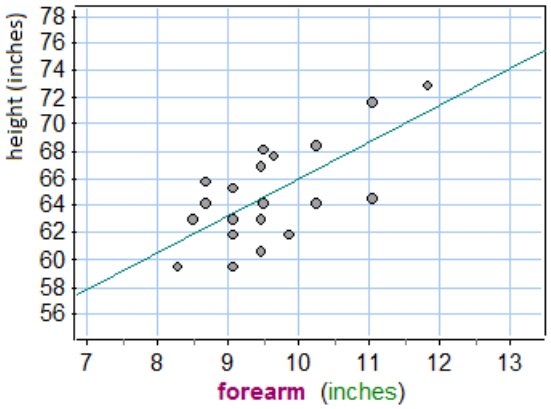
NEXT STEPS

Using a Line to Make Predictions

3 The scatterplot has a positive linear association. The correlation is 0.68, which is pretty strong. So, it makes sense to use a linear model to summarize the relationship between the forearm and height measurements. There is one line that is considered the best description of how height and forearm length are related. You will learn more about how to find this line in future lessons. For now, you will use technology to find the equation of this line.



A Use the graph of the best-fit line to predict the height of the mystery student.

B The equation of this line is approximately predicted height = 2.7(forearm length) + 39.

$$\hat{y} = 2.7x + 39$$

(Notice that when you use letters to represent variables in the prediction line, you put a "hat" on the *y* and write $\hat{y}$ instead of *y*. The hat is a signal that the variable is *predicted* values, not actual data values.)

Use the equation to predict the height of the mystery person.

C Is the height of Jane Doe 1, 2, or 3 closest to the predicted height of the mystery student given by the line? (Of course, this does not guarantee that you have correctly identified the mystery student, but it suggests that one student's height, together with the 10-inch forearm measurement, fits the linear pattern in the data better than the other students.)

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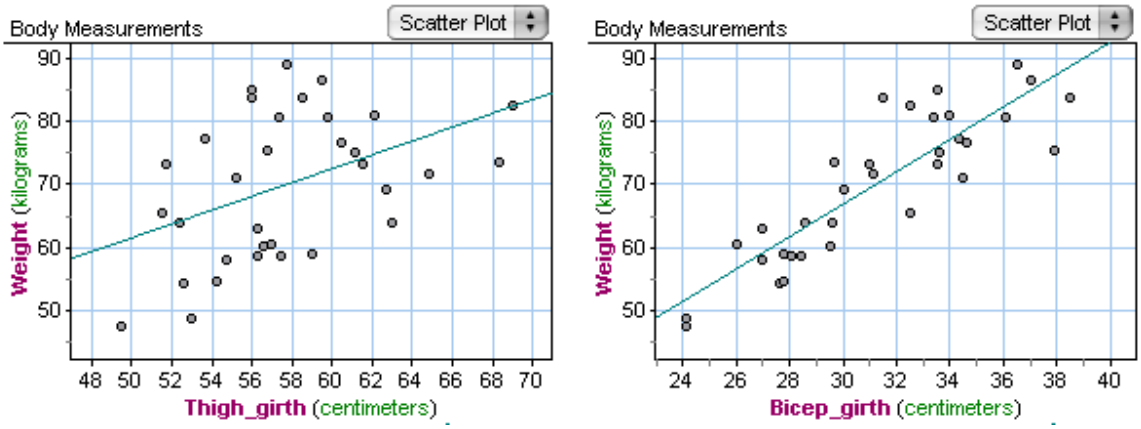
4 The scatterplots below are graphs of body measurements in centimeters for 34 adults who are physically active. These data are a random sample taken from a larger nonrandom data set gathered by researchers investigating the relationship of various body measurements and weight. Girth is the measurement around a body part.
(Retrieved from www.amstat.org/publications/jse/v11n2/datasets.heinz.html)



A Based on these data, which do you think is a better predictor of an adult's weight: thigh girth or bicep girth? Why?

B Adriana has a thigh girth of 57 centimeters and a bicep girth of 25 centimeters. Predict her weight using the measurement that you think will give the most accurate prediction, and then plot Adriana on the scatterplot that you used to make her weight prediction.

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C The equations of the two lines shown are

weight = 6.3 + 1.1(thigh girth) weight = –10.5 + 2.6(bicep girth)

Predict Adriana's weight using the equation that you think best predicts weight.

D Of course, you do not really know Adriana's weight. How accurate do you think the line's prediction of Adriana's weight is? Choose the option that is the most reasonable and explain your thinking.

- Very accurate (within a range of plus or minus 1 kilogram).
- Somewhat accurate (within a range of plus or minus 5 kilograms).
- Not very accurate (within a range of plus or minus 10 kilograms).

5 In previous lessons, you studied the concept of correlation to describe the strength and direction of the linear association between two quantitative variables. Now you are working on predicting the value of one variable based on the other. Are these two ideas related? Explain your reasoning.

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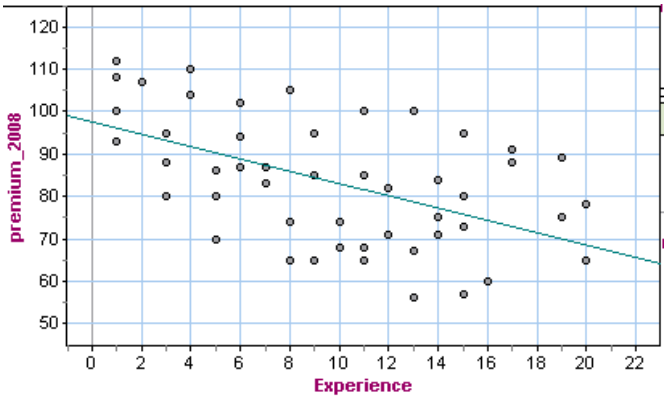
TRY THESE

In 2008, a statistics student gathered data on monthly car insurance premiums paid by students and faculty at Los Medanos College. Relating monthly car insurance premiums to years of driving experience, she found a linear relationship and used statistical methods to get the following equation:

predicted monthly car insurance premium = 97 – 1.45(years of driving experience)



6 Predict the monthly car insurance premium paid by someone who has been driving 12 years.

7 Which of the following methods can be used to make the prediction?

A Find 12 on the horizontal axis, trace up to the line, and read off the corresponding value on the *y*-axis.

B Substitute 12 in the equation, and calculate the predicted premium.

C Look at the data and find a person who has been driving 12 years. Report the premium paid by this person.

D Both A and B.

E Both B and C.

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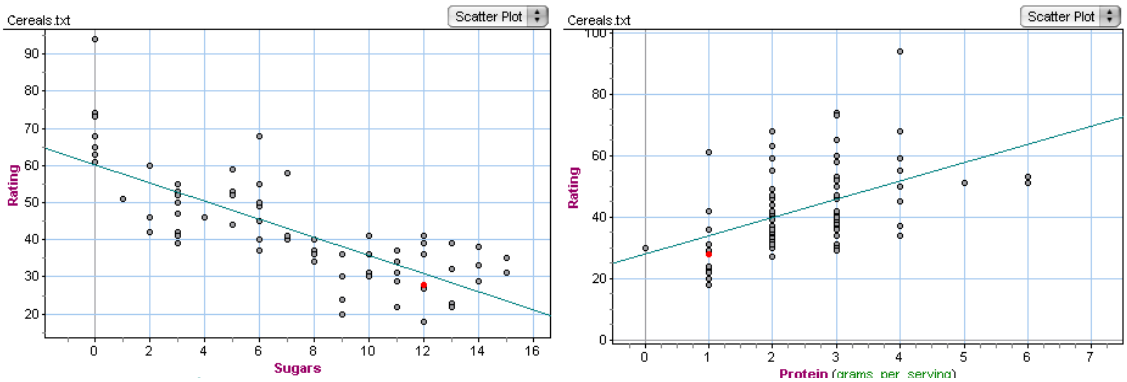
TAKE IT HOME

1 Here you return to the data set for the 77 breakfast cereals you investigated at the beginning of Module 3.



ratings = 60 – 2.43(sugars)

ratings = 8 + 5.96(protein)

Two new cereals are being rated by *Consumer Reports*. Cereal A has 10.5 grams of sugar in a serving and Cereal B has 2.5 grams of protein in a serving.

A Predict the *Consumer Reports* rating for the two cereals using the best-fit lines.

B For which cereal do you think your prediction is probably more accurate (more likely to be closer to the actual *Consumer Reports* rating)? Why?

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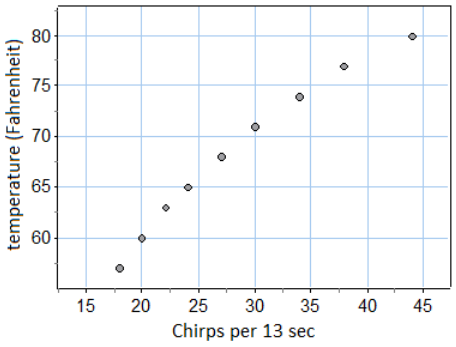
2 Can the rate that crickets chirp be used to predict the temperature?



According to Tom Walker, an entomologist with the University of Florida, all crickets are pretty good thermometers because they chirp at a rate that is related to the temperature. The chirping noise results when the cricket rubs its wings together. A cricket studied by Walker, the snowy tree cricket (*Oecanthus fultoni*), chirps at a rate that is slow enough to count. These crickets also synchronize their wing rubbing so determining the chirp rate easier. The snowy tree cricket is found throughout the United States. To hear the snowy tree cricket go to http://entnemdept.ufl.edu/walker/buzz/585a.htm.

A The scatterplot is a graph of data from the June 1995 issue of *Outside* magazine. Use the scatterplot to predict the temperature when the snowy tree crickets are chirping at a rate of 40 chirps every 13 seconds.

B How accurate do you think your prediction is? Choose the option that is most reasonable and briefly explain your thinking.

- Very accurate (within a range of plus or minus 1 degree).
- Somewhat accurate (within a range of plus or minus 5 degrees).
- Not very accurate (within a range of plus or minus 10 degrees).

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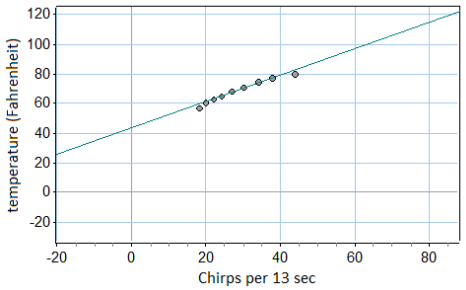
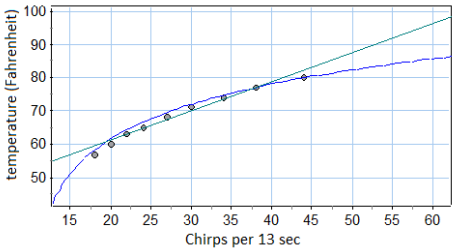
C This is the same data graphed in two different windows. The data has been zoomed out by expanding both axes. The line pictured is the best-fit line:

temperature = 0.88(chirp rate) + 43



For some chirp rates, this line gives very accurate predictions of the temperature. However, the data are actually slightly curved, so that for chirp rates above 50 a nonlinear model might give more accurate predictions. One possible nonlinear model is also shown.

The line also has limitations in that some chirp rates are meaningless and should not be used to make predictions.



In statistics, *extrapolation* is the process of using a statistical model (like a line) to make predictions outside the range of the available data. To use a statistical model to make a prediction for an explanatory variable value that is outside the range of values in the data set requires that we make the assumption that the pattern observed in the data continues outside this range. If this is not the case, predictions are unreliable and may be very far off from the actual response variable values. You should be very cautious in doing this.

Illustrate the concept of extrapolation by identifying a point on the line that gives either meaningless results or unreliable results. Explain how this point illustrates the concept of extrapolation.

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3 **A Note About Statistical Vocabulary:** A variable that is used to predict the value of another variable is called the **predictor variable**, also known as the **independent variable** or **explanatory variable**. The other variable, whose values you are predicting, is called the **response variable**, also known as the **dependent variable**.

A The introductory problem in this lesson has forearm lengths and heights for 21 female college students. In this situation, which variable is the predictor?

B The cereal data has the amount of sugar in a serving and the *Consumer Reports* rating. In this situation, which variable is the predictor?

C When graphing bivariate data, you put the predictor variable on the (*choose one:* horizontal axis, vertical axis).

D Using measurements of temperature (°F) and the chirp rate of the snowy tree cricket (measured in number of chirps in 13 seconds), students use technology to find a best-fit line. However, some students use temperature as the predictor variable, and others use chirp rate as the predictor variable. For which of the two lines below is temperature treated as the predictor variable?

$$\text{temperature} = 0.88(\text{chirp rate}) + 43$$
$$\text{chirp rate} = 1.1(\text{temperature}) - 47$$

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